DISCUSSION

Trauma is the leading cause of death in young adults. (1) Thoracic trauma comprises 10-15% of all traumas. (3) It directly accounts for approximately 25% of trauma related mortality and is a contributing factor in another 25%. (4) Penetrating thoracic trauma accounts for almost 33% of total chest trauma. It is mostly attributed to violence. Penetrating cardiac injuries are associated with high mortality rates. The majority of patients die on the scene despite aggressive resuscitation attempts.

Generally, penetration with sharp objects is associated with a better outcome than penetration that results from gunshot and non-penetrating injuries. (19) The clinical presentation ranges from hemodynamic stability to acute cardiovascular collapse and fatal cardio-pulmonary arrest. (19) Multiple injuries have greater mortality rate. (12) Early and balanced use of blood products appears to be lifesaving and reducing total blood use. Decompression of pericardial tamponade and control of external bleeding can save more lives. (13, 17, 22)

The initial evaluation of a penetrating chest trauma includes physical examination and chest radiography. The sensitivity and specificity of both examinations for diagnosing cardiac injury is relatively low. (10) FAST is currently the most widely practiced method for diagnosing traumatic haemo-pericardium in the ED. It has the desirable qualities of being rapid, non-invasive, readily available and repeatable. Echo is recommended as the gold standard of care in stable patients with penetrating cardiac injury. (27) CT can detect significant injuries, however, only patients who are haemo-dynamically stable enough to leave the emergency department should be evaluated using this tool. Unstable patients with clear signs of tamponade or hemodynamic instability should be taken immediately to the operating room for urgent surgical intervention. (27) Electrocardiogram (ECG) has become a prominent part of the work up of a patient admitted with a penetrating chest injury that may have resulted in cardiac damage. (32) Complications are common and may occur immediately. The most common early complications are respiratory in nature. (32)

The aim of this clinical study was to evaluate patients with penetrating cardiac injuries who were admitted to Alexandria Main University Hospital (AMUH) during a period of one year (June 2013 – June 2014). This study included 35 patients presented to the ED with penetrating cardiac injury; all patients included in the study were divided into 2 groups according to the mechanism of injury and 3 groups according to the age of the patients.

Regarding to the demographic data, there was no significant difference between the patients with stab injury and patients with gunshot injury (p = 0.760). The 35 patients were male. Males are more mobile, physically active and they are predominantly involved in violent trauma especially at this period. 60% of them had stab injury. Their mean age was 24.66±9.61. The age of the majority of them was between 18-40 years. While 40% of them had gunshot injury, their mean age was 29.07±10.37. The age of the majority was between 18-40 years, (Table 1).

These results are in agreement with many authors in literature. Jagelavicius *et al.* (40) studied 193 patients over 28 year period, 85% of them were males, 91% patients were stab injury and only 5% patients had gunshot injury. Onan *et al.* [41] studied 104 patients over 10 year period. 84% of them were males, with a mean age of 32.5±8.2. Stab wounds were the leading cause of penetrating injuries. Prajapati *et al.* [42] studied 42 patients, 83.3% were males and their mean age was 35.4 years. While the most affected age was in the range of 20 to 49 years. Ezzine *et al.* [43] studied 19 patients over 17 year period, 89% were men, with a mean age of 25 years. All patients had cardiac injury resulting from stab wounds.

The information of the time elapsed between trauma and arrival at the hospital; the amount of bleeding and the treatment received prior to the arrival to the hospital were not available for analysis. Hence, their effect on morbidity and mortality in those patients were not achieved.

Regarding to the physiological parameters, there was a significant difference between patients with stab injury and patients with gunshot injury. The mean systolic blood pressure (SBP) and pulse for patients with stab injury were 60.47±37.87 mmHg and 85.24±56.35 b/min, respectively. 85.7% of them were shocked (SBP was ≤ 90 mmHg and pulse was < 60 or >100 b/min), which was significantly lower (p =0.022) than the SBP of patients with gunshot injury (82.14±48.86 mmHg). There was no significant difference (p =1.0) as regard to the pulse of patients with gunshot injury (96.43±41.62 b/min), (Table 2-3) (Figure 13 a, b).

These results are in accordance with Serdar *et al.* [32] they reported that SBP of patients with stab injury was 78.12±31.811 mmHg which was lower than the SBP in patients with gunshot injury (81.58±31.136mm Hg), but there were no significant differences (p = 0.496). Ngatchou *et al.* [44] reported that 84% of the stab injured patients were unstable. Ezzine *et al.* [43] reported that 42% of the stab injured patients were critically unstable (systolic blood pressure ≤ 90 mm hg), while 37% of them were hemodynamically stable.

The mean respiratory rate (RR) of patients with stab injury was 28.23±19.88 breath/min, 90.5% of them had abnormal respiratory rate (< 12 and > 20 breath /min), which was significantly higher (p = 0.040) than the RR of patients with gunshot injury (25.79±13.34 breath/min). The mean Glasgow coma scale (GCS) of patients with stab injury was 11±5.05. 38, which was significantly lower (p = 0.046) than the GCS of patients with gunshot injury (13±3.7). Central venous catheter was inserted in 11patients with stab injury and the mean central venous pressure (CVP) was 17.55±10 cm H_2O, which was significantly higher (p = 0.039) than that inserted in 8 patients with gunshot injury (mean CVP was 14.13±7.06 cm H_2O), (Table 2-3) (Figure 13 c-e).

All these parameters indicated that patients with stab injury show more hemodynamic instability than patients with gunshot injury. To the best of our knowledge no information are available on these parameters and their association to morbidity and mortality related to the mechanism of injury. Ngatchou *et al.* [44] reported that 11 patients with stab injury were unstable and only 2 patients were stable, while the gunshot injury patient was stable but they did not mention clearly what parameters used to assess the instability in those patients in addition to SBP and pulse rate.

There were significant differences among the SBP, Pulse, RR, GCS and CVP of patients with age ≤ 18 years, patients with age between 18-40 years and patients with age > 40 years. The mean SBP of patients with age ≤ 18 years (55±35.46 mmHg) was significantly lower (p = 0.012) than patients with age between 18-40 years (75.21±45.31 mmHg) and patients with age > 40 years (77.5±27.54mmHg). The pulse of patients with age ≤ 18 years (80±66.96 b/min) was significantly lower (p = 0.041) than patients with age between 18-40 years (89.31±48.70 b/min) and patients with age > 40 years (87.5±59.65 b/min). The mean RR of patients with age ≤ 18 years (22.5±17.32 breath/min) was significantly lower (p =0.027) than the mean RR of patients with age between 18-40 years (28.09 ±17.59 breath/min) and patients with age > 40 years (30±18.26 breath/min). The mean GCS of patients with age ≤ 18 years (10.5±5.32) was significantly lower (p = 0.005) than GCS of patients with age between 18-40 years (12.44±4.57) and patients with age > 40 years (12±6). The mean CVP of patients with age ≤ 18 years (13 cm H_2O) was significantly lower (p = 0.038) than the patients with age between 18-40 years (14.8 ±8.27 cm H_2O) and patients with age > 40 years (17.5 cm H_2O), (Table 4-5 and Figure 14 a-e).

These results indicated that patients with age between 18-40 years had better compensatory mechanisms to cope with the stress of the trauma than patients with age ≤ 18 years. Our result was matching with Ngatchou *et al.* [(44)] they reported that all patients with age ≤ 18 years were vitally unstable which could be attributed to the diminished compensatory mechanisms to the trauma.

Regarding to the clinical signs, there was a significant difference between patients with stab injury and patients with gunshot injury regarding to the associated injuries. 33.3% with stab injury had other associated injuries, which was significantly lower (p = 0.046) than the patients with gunshot injury (78.6%). Patients with stab injury had 5.7% abdominal injury, 14.2% of each scalp injury or extremities, 2.8% with neck injury, which was significantly lower (p =0.02) than patients with gunshot injury who had 14.2% abdominal injury, 17.1% extremities injury, 2.8% scalp injury and 25.7% neck injury. Meanwhile 2.8% with age ≤ 18 years had other associated injuries, while 42.85% with age between 18-40 years had other associated injuries and 5.7% with age > 40 years had other associated injuries. But the differences were not significant (p = 0.52), (Table 6 - 8 and Figure 15 c - 16 c). These results indicated the prevalence of high violence between patients with age between 18-40 years.

The injury severity score (ISS) of stab injury patients (18.23±4.16) was significantly lower (p =0.087) than the ISS of gunshot injury patients (20.50±2.93). The revised trauma score (RTS) of stab injury patients was 5.07 ±2.67, while RTS of gunshot injury patients was 6.41±2.10, but there was no significant difference (p = 0.124). The trauma revised injury severity score (TRISS) of stab injury patients was 79.21±33.01, while gunshot injury patients was 89.63±22.08, moreover, there was no significant difference (p = 0.309). There were no significant differences among the change in ISS (p = 0.509), RTS (p = 0.524) and TRISS (p = 0.562) at the time of presentation of patients with age ≤ 18 years, patients with age between 18-40 years and patients with age > 40 years, (Table 2-4). This may be explained as gunshot injuries (pellets) affect a large surface area of the patient's body without getting in close contact with them unlike stab injuries that need direct contact with the victims who can show signs of resistance and limitations of the injury.

These results are in accordance with many authors. Serdar *et al.* [32] reported that patients suffered from gunshot injury tended to have a higher ISS than those admitted with stab injury, but the difference was not significant (overall ISS, 18.92 ± 9.98; range 9–50; for gunshots, 20.63 ± 10.42; for stab wounds, 17.72 ± 9.53, $p = 0.07$). While 19% with stab injuries had other associated injuries which was significantly lower than 43% with gunshot injury who had other associated injuries ($p = 0.01$). To the best of our knowledge no one compared these parameters in relation to different age groups.

Meanwhile, there was no significant difference between patients with stab injury and patients with gunshot injury regarding to the condition of the neck veins ($p = 0.44$) and chest auscultation ($p = 0.14$). Similar results were observed for patients with age ≤18 years, patients with age between 18-40 years and patients with age > 40 years. ($p = 0.28$ and $p = 0.34$, respectively), (Table 6-7 and Figure 15 a-b, 16 a-b).

Congested neck veins and limitation of air entry on auscultation were predominant in most of patients and could not be reliable factor to differentiate between those have cardiac tamponade and those have not. This could be attributed to the strain and increased intra-thoracic pressure related to pain, associated heamothorax or pneumothorax in those patients at the time of presentation.

Regarding to the investigations performed preoperatively, there was no significant difference between patients with gunshot injury and patients with stab injury. Similar results were observed for patients with age ≤ 18 years, patients with age between 18-40 years and patients with age > 40 years.

FAST was the main diagnostic tool used in this study as it was readily available when demand. FAST was done for all the patients with the exception of four patients. Three of them with stab injury were unstable and arrested before reaching the OR. The fourth with gunshot injury was taken directly to the OR and arrested intra-operatively ($p = 0.75$). All of them were between 18-40 years ($p = 0.46$), (Table 9-11, Figure17 a and Figure 19 a).

CT chest was done on 5 patients with stab injury and 10 patients with gunshot injury ($p = 0.46$). Eleven patients were between 18-40 years, two patients were between 18-40 years and the other 2 patients were ≤ 18 years ($p = 0.82$), (Table 9-11, Figure 17 b and Figure 19 b).

Chest x ray was done on 5 patients with stab injury while it was done in 9 patients with gunshot injury ($p = 0.28$). Twelve patients were between 18-40 years, one patient was > 40 years and the other patient was ≤ 18 years ($p = 0.61$), (Table 9-11, Figure17 c and Figure 19 c).

ECG was done on 2 patients with stab injury and 3 patients with gunshot injury ($p = 0.55$). Three patients were between 18-40 years and 2 patients were > 40 years ($p = 0.039$),

(Table 9-11, Figure 17 d and Figure 19 d).

These results differed from those reported by Kong *et al.* [45]. They reported that over six years period operated 109 patients on predominantly clinical grounds and only 10 patients underwent FAST as part of a diagnostic workup before operative explorations. They did not have much experience with FAST. Moreover, Onan *et al.* [41] reported that CT was performed in most of cases and Echo was used in some of the stable patients. In this study, FAST was readily available when demand and it used in the assessment in combination with the clinical signs evolved during examination with exception of patients extremely critical where the clinical signs were the predominating assessment tools. In contrast to Onan *et al.* [41] we consider CT examination and Echocardiography in all the patients harmful and should be used in highly selected patients whose conditions permit these investigations to be performed.

ABGs were done on 5 patients with stab injury and 5 patients with gunshot injury ($p = 0.37$). Seven patients were ≤ 18 years, one patient was between 18-40 years and the other patient was > 40 years ($p = 0.96$). The majority had acidosis ($p = 0.35$), (Table 9 – 11 and Figure 18).

Predominance of acidosis respiratory, metabolic or mixed indicates a state of shock and hypo-perfusion. These results were in accordance with Kong *et al.* [45] they reported that the mean preoperative pH, base excess and lactate were 7.2, 8.5 and 7.0 mmol/L, respectively.

Regarding to operative intervention, there was no significant difference between the patients with stab injury and patients with gunshot injury according to the indication for operative intervention ($p = 0.35$). Shock was the most common indication for operative management in this study (64.7%), (Table 12)

Kang *et al.* [20] reported that non-specific signs of shock such as agitation, tachycardia, tachypnea, hypotension, diaphoresis and cool extremities may dominate the clinical picture of cardiac injury. Onan *et al.* [41] reported that the most common indication of early procedures was pericardial tamponade in 61.5%.

There was a significant difference between patients with stab injury and patients with gunshot injury according to type of operative management ($p = 0.019$). Similar results were observed for patients with age ≤ 18 years, patients with age between 18-40 years and patients with age > 40 years ($p = 0.026$). Five patients with positive FAST were stable and did not need any operative intervention. While 27 patients needed operative intervention, 17 patients had left anterior thoracotomy which was the main approach used in this study, 66.6% with stab injury and 21.4% with gunshot injury. While 6 patients needed chest tube insertion, 4.7% with stab injury and 35.7% with gunshot injury. On the other hand, only one patient with gunshot injury had median sternotomy. The majority was between 18-40 years. Finally 3 patients had laparotomy, 9.5% with stab injury and 7.1% with gunshot injury all of them were between 18-40 years, (Table 13-14 and Figure 20-21).

These results were in accordance with Jagelavicius *et al.* [40] they reported that the most frequent operative approach was left anterolateral thoracotomy (84.4%); right thoracotomy (12.9%) patients and longitudinal sternotomy (2.7%). Ceviker *et al.* [46] reported that 15.6 % with right thoracotomy, 29.2% with left thoracotomy, and 15.6% with bilateral thoracotomy or median sternotomy (MS) with thoracotomy and (MS) in 39.6% of the patients. But differed from Clarke *et al.* [47] they reported that the role of conservative management of minor grades of cardiac injury awaits further clarification. The surgical access was via median sternotomy in 56 patients and lateral thoracotomy in 52 patients.

Regarding to the time spent before going to operating theater, there was a significant difference between patients with stab injury and patients with gunshot injury. Patients with stab injury had mean time to operating theater (4.79±2.19 h) significantly lower (p = 0.047) than patients with gunshot injury (5.40±1.14 h), the majority of the patients took > 3 h, (Table 15, Table 16 and Figure 22).

There were significant differences among patients with age ≤ 18 years, patients with age between 18-40 years and patients with age > 40 years (p = 0.010) regarding to the time spent before going to operating theater. Five patients had time ≤ 3 h before going to operating theater, 2 patients were between18-40 years and 2 patients were > 40 years, and one patient was ≤ 18 years. While seventeen patients had time > 3 h before going to the operating theater, the majority of them were between 18-40 years, (Table 17 and Figure 23). The delay in time to OR was attributed to unavailability of blood products to transfuse and unavailability of a skillful surgeon to perform the operation. In addition to the time spent in some patients who were vitally stable enough to be taken for further investigations as chest X-ray and CT till definite diagnosis occur or they showed instability.

This result differed from Serdar *et al.* [32] they reported that 132 patients underwent a thoracotomy within 4 h after admission; 20 patients, within 5–8 h; and 6 patients, within 9–24 h. Mean time to thoracotomy was 3.45 ± 3.16 h. Also, Clarke *et al.* [47] reported that 53 patients were in the operating room within 4 h (average, 93 minutes; range, 15-300 minutes). Twelve patients had much longer delays of 12 to 48 h.

Regarding to the intra-operative findings, the most common injured chamber in this study was the right ventricle. There were significant differences among patients with age ≤ 18 years, patients with age between 18-40 years and patients with age > 40 years. The right ventricle was injured in 9 patients. The left ventricle was injured in 4 patients. The majority of them were between 18-40 years. Finally complex injury (right ventricle and interventricular septum injury) was seen in only one patient. His age was > 40 years (p = 0.038). Meanwhile there was no significant difference between patients with stab injury and patients with gunshot injury (p = 0.85), (Table 18-19 and Figure 24-25).

The anatomy of the heart determines the likelihood of the chamber injury, the right ventricle position in the anterior surface make it more prone to injury. Our results are in agreement with those of Bruno *et al.* [15] they reported that the most frequent injuries were in the right ventricle (39.8%), followed by left ventricle (33.3%). The results differed from

Kamalı *et al.* [(48)] they reported that 15 patients had left ventricular injury, 4 patients had right ventricular injury and 4 had right atrial injuries.

The diaphragm was the most frequently injured organ in this study. There were significant differences among patients with age ≤ 18 years, patients with age between 18-40 years and patients with age > 40 years as regard to intra-abdominal injury. Single intra-abdominal injury was seen in 7 patients. While multiple intra-abdominal injury was seen in 4 patients, the majority of them were between 18-40 years ($p = 0.035$). However there was no significant difference between patients with stab injury and gunshot injury as regard to intra-abdominal injuries ($p = 0.23$), (Table 20-21 and Figure 26).

These results are in accordance to Onan *et al.* [(41)] they reported that diaphragm rupture was seen in 3 patients and hepatic laceration in 2 patients. On the other hand, our results differed from Kong *et al.* [(45)] they reported that the most common intra-abdominal injuries were the liver. This could be explained by the site of the injury, mechanism of insult and number of stabs or shots. These aspects were not mentioned in any studies including our study.

Regarding to blood loss and blood transfusion, there was no significant difference between patients with stab injury and patients with gunshot injury as regard to the initial chest tube loss ($p = 0.41$). There was a significant difference between patients with stab injury and patients with gunshot injury as regard to the ongoing chest tube loss. Four patients had ongoing chest tube loss (575±221.74 ml), all were with gunshot injury ($p = 0.001$), (Table 22).

These results differed from Serdar *et al.* [(32)] they reported that the mean blood loss with the ongoing chest tube blood loss tended to be greater for stab wounds (829.03 ± 355.15 ml) than for gunshot wounds (715.38 ± 341.19 ml), but the difference was non-significant ($p = 0.32$).

There were significant differences among patients with age ≤ 18 years, patients with age between 18-40 years and patients with age > 40 years in blood transfusion. Two patients were ≤ 18 years transfused (2500±1224 ml) which was significantly lower ($p = 0.04$) than the 21 patients with age between 18-40 years (4000±2500 ml) and 3 patients with age > 40 years (4333±1932 ml), (Table 23 and Figure 27). This result could be attributed to the majority of the patients lie within that age group.

Regarding to postoperative hospital and ICU stay, there was a significant difference between patients with stab injury and patients with gunshot injury. Patients with stab injury had total hospital stay (5.61±1.55 days) and the ICU stay (3.15±0.55 days) significantly lower ($p = 0.014$ and $p = 0.039$, respectively) than patients with gunshot injury (12.5±11.73 days and 5±3.3 days, respectively), (Table 24).

This result is in accordance with Serdar *et al.* [(32)] they reported that the mean length of hospital stay (LOS) was 10.65 ± 8.30 (range, 5–65) days, with a significantly longer

LOS for gunshot victims (13.53 ± 9.92 days) than for stabbing victims (8.76 ± 6.42 days; $p < 0.001$). Neither his study nor this study could explain the longer LOS for gunshot victims.

Regarding to postoperative complications, postoperative pain was the most common complication in this study. There was a significant difference between patients with stab injury and patients with gunshot injury. All patients had postoperative pain. The majority had postoperative fever. On the other hand, only 4 patients had residual pneumothorax, 75% of them with gunshot injury. Two patients had postoperative pneumonia, all of them with gunshot injury ($p = 0.042$), (Table 25).

This result differed from Onan *et al.* [41] they reported that atelectasis was the most common morbidity, with an incidence of 60%, followed by respiratory failure in 9.6% of patients. This could be attributed to the postoperative analgesic treatment regimen in our center which precludes the use of narcotics except in highly selected patients. In addition, the difference in the pain threshold could not be compared. Furthermore, most of the patients with such trauma presented to the ER were drug addicts and hence the postoperative analgesia could not achieve the effect desired.

Regarding to parameters affecting mortality, the overall mortality in this study was 22.8%. This value was lower than the value (39%) reported by Ceviker *et al.* [46] and higher than the value (10%) reported by Clarke *et al.* [47] This variation in mortality rate is attributed to the difference of the surgical skills between surgical teams in the three hospitals in addition to the other factors which may not be mentioned in the three studies like time elapsed between injury and arrival to the ED, time elapsed from the arrival to ED and transfer to operating theater and presence of other pre-operative co-morbidities.

Three patients arrested on arrival, all of them had SBP ≤ 90 mmHg, while five patients arrested intra-operatively with mean SBP was 58±34.93mmHg, all of them had SBP ≤ 90 mmHg which was significantly lower ($p = 0.021$) than the other twenty-seven patients who survived (Mean SBP 81.11±36.83 mmHg), (Table 26 and Figure 28 c).

This was in accordance to many authors as Ceviker *et al.* [46] they reported that only systolic blood pressure consistent predicting factor in the outcome as 59.4% of the patient's blood pressure was below 80 mm Hg and the mortality rate in their study was 97.3%. Meanwhile, Serdar *et al.* [32] reported that patients who died had a significantly lower SBP on presentation at the ED (42.94 ±36.702 mm Hg) than those who survived (83.96 ± 27.842 mm Hg; $p = 0.001$).

Two patients from those who were presented by tamponade were arrested intra-operatively which was significantly lower ($p = 0.023$) than the six patients who survived (Figure 28 g). This was in favor with the theory stating that tamponade had a protective effect and increase survival rate in those patients. Contrary to the study of Ceviker *et al.* [46] they reported that the mortality rate was higher in the patients who had cardiac tamponade.

The cardiac tamponade may generally indicate presence of cardiac penetration. This may necessitate immediate surgery. Uncertainties in the undefined period in which tamponade is providing a protective effect by preventing the bleeding and thereby preventing hypovolemic shock, could lead to a harmful effect. After this undefined period of time, tamponade itself induces adverse effects on cardiac function which is critical and the cardiovascular collapse may induce an exhaustion of cardiac reserve irrespective of whether the surgery was successful or not.

Three patients arrested on arrival with mean GCS 5±4.36, while five patients arrested intra-operatively with mean GCS 10.6±4.98, which was significantly lower ($p = 0.035$) than the twenty-seven patients who survived with a mean GCS of 13.19±3.91. The majority of the arrested patients had GCS ≤ 9, while the majority of the survived patients had GCS > 9. This means that high score of GCS is a one of the good outcome determining factors. (Table 26 and Figure 28 d).

This result agreed with those reported by Bruno *et al.* [15] they reported that GCS < 8 ($p = 0.0005$) was significantly associated with mortality. Moreover, O'Connor *et al.* [49] reported that patients who were unconscious on admission had mortality rate reaching 94%. Unfortunately, they didn`t specify the level of consciousness on GCS scale. Ceviker *et al.* [46] they reported that GCS was significantly lower in their study than the previous studies in the literature.

The three patients who arrested on arrival had ISS 16, RTS 4.49±3.91 and TRISS 68.46±46.85, while five patients who arrested intra-operatively had ISS 16, RTS 2.72±3.72 and TRISS 47.76±45.68, which was significantly lower ($p = 0.026$, $p = 0.007$ and $p = 0.003$, respectively) than the twenty-seven patients who survived (ISS 20.07± 3.91, RTS 6.27±1.66 and TRISS 91.64±16.93), (Table 26).

These results were in accordance with Bruno *et al.* [15] they reported that low RTS ($p = 0.0629$) was significantly associated with mortality. On the contrary, Serdar *et al.* [32] reported that high ISS ($p = 0.001$) was significantly associated with mortality. Meanwhile, none had mentioned TRISS and its relation to mortality.

The five patients who arrested intra-operatively had blood transfusion (Mean 3250±1500 ml), which was significantly lower ($p = 0.001$) than the twenty-seven patients who survived (Mean 3772.7±2483.1 ml). This was mainly one of the causes of death in these patients as blood loss was highly expected in such operations and unavailability of blood products to transfuse would definitely led to exsanguination in these patients (Table 26).

This differed from the results of Serdar *et al.* [32] they reported that the mean amount of transfused blood to the non-survivor was 7.18±4.87 L in comparison to the survivor group (Mean 3.36 ±1.80), ($p = 0.005$).

The five patients who arrested intra-operatively had mean time to go to operating theater 7±1.22 h, which was significantly higher ($p = 0.019$) than the twenty-seven patients who survived (4.32±1.77 h). The majority of them took >3 h (Table 26). Unavailability of skillful surgeon and delay in diagnosis of the injury were the main cause for the delay in those patients and the cause of their death.

These results differed from the results reported by Serdar *et al.* (32) they found that the mean time to the OR for the non-survivor was 1.94±1.71 in comparison with 3.30±3.58 for the survivors, but the difference was insignificant ($p = 0.125$).

Mortality was not related to age ($p = 0.33$), mechanism of injury ($p = 0.16$), presence of other associated injuries ($p = 0.16$) and associated injuries encountered intra-operatively ($p = 0.16$), (Table 26 and Figure 28 a, b, e, h).

These results were in accordance with Serdar *et al.* (32) they reported that mortality of patients with stab wounds was (8.6%) compared with (13.8%) of patients with gunshot wounds ($p = 0.29$). The mean age in non-survivor was 24.18±7.09 years in comparison with the mean of age in the survivor (25.90±9.57 years) ($p = 0.373$). But it differed from Serdar *et al.* (32) they reported that mortality was significantly associated with diaphragmatic injury ($p = 0.01$). Onan *et al.* (41) reported that high mortality risk was related to presence of associated injuries. Ceviker *et al.* (46) reported that higher mortality rates depend on the mechanism of injury and presence or absence of associated lesions.

Some factors related to the trauma could be missed during history taken from those patients and inaccuracy in this data collected could be reflected on the result analysis. Most of those patients were diagnosed on clinical basis with a help of the available and rapid investigative tool present at the hospital according the stability of the patient. The rapidity and accurate diagnosis in those patients and levitation of time consumption between investigations was the reason of the low mortality in this study.

Regarding to postoperative follow up visits, the unavailability of Echo make it hard to do immediately postoperative, and with the lack of compliance or ignorance of the patients about the importance of the postoperative visits, only 3 patients with stab injury done Echo which showed minimal pericardial effusion. ECG was done for all patients immediately postoperative showing sinus tachycardia which is either due to the pain or the presence of anemia (Table 27, Figure 29 a, b and Figure 30).

SUMMARY

Penetrating cardiac injuries are associated with high mortality rates. The majority of patients die on scene despite aggressive resuscitation attempts. Generally, penetration with sharp objects is associated with a better outcome than penetration that results from gunshot and non-penetrating injuries. The clinical presentation ranges from hemodynamic stability to acute cardiovascular collapse and fatal cardiopulmonary arrest. Survival is greater for cardiac injuries compared to chest injuries, while abdominal injuries have a worse prognosis. Early and balanced use of blood products appears to be lifesaving and reducing total blood use.

The initial evaluation of a penetrating chest trauma includes physical examination and chest radiography. Currently, FAST is the most widely practiced method for diagnosing traumatic haemopericardium in the Emergency Department (ED). Echocardiography is recommended as the gold standard of care in stable patients with penetrating cardiac injury. CT is performed only with patients who are hemodynamically stable enough to leave the ED. Unstable patients with clear signs of tamponade or hemodynamic instability should be taken immediately to the operating room for urgent surgical intervention. Electrocardiogram has become a prominent part of the work up of a patient admitted with a penetrating chest injury that may have resulted in cardiac damage. Complications are common and may occur immediately. The most common early complications are respiratory in nature.

The aim of this clinical study was to evaluate patients with penetrating cardiac injuries who were admitted to Alexandria Main University Hospital (AMUH) during a period of one year (June 2013 – June 2014). All patients included in the study were allocated into two groups according to the mechanism of injury (stab and gunshot) and three groups according to the age ($\leq$ 18, 18-40 and > 40 years). The total number of thoracic injury during this period was 1120 patients, 409 patients had penetrating thoracic injury, and only 35 patients had isolated penetrating cardiac injury representing 8.6%.

All patients included in this study were males. Most of them had stab injury; their age was mainly between 18-40 years. This may be attributed to their physical activity and predominant involvement in violent trauma. The majority of the patients regardless the mechanism of injury were shocked at time of presentation. But patients with age between 18-40 years show more hemodynamic stability than patients with age $\leq$ 18 years and patients with age > 40 years.

FAST was readily available and was used in the assessment in combination with the clinical signs evolved during examination except in patients were extremely critical where the clinical signs were the predominating assessment tools. While CT- scan was used in more stable patients.

Shock was the most common indication for operative intervention where left anterior thoracotomy was the most common approach used in this study. Patients with stab injury had initial chest tube blood loss more than patients with gunshot injury while patients with gunshot injury had ongoing chest tube blood loss more than patients with stab injury. Intra-operatively the right ventricle was the most common injured chamber as it is comprising

the majority of the anterior surface of the heart that make it more prone for injury, while diaphragm was the most common thoraco-abdominal organ injured.

Patients with stab injury had total hospital stay and ICU stay shorter than patients with gunshot injury. The most common postoperative complication was postoperative pain. Mortality was significantly associated with patients who had less SBP, with patients who had GCS < 9 on presentation, with patients who not presented with tamponade, with patients who had low ISS, with patients who had low RTS, with patients who had low TRISS, with patients who had less blood transfusion and with patients who had longer time before Operative theater. While mortality was not associated with age, mechanism of injury, other associated injuries and associated intra-abdominal injuries.